



Lean Six Sigma Toolkit

Lean Overview



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☐ **Purpose & Agenda**

- The purpose of this program is to provide the key concepts and skills for understanding some of the basic tools used in evaluating a process
- Our Agenda
 - Overview of the concepts and tools used to create a lean enterprise

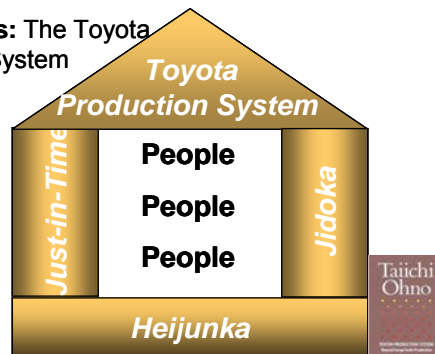
☐ **Objectives and Expectations**

- By the end of this module, participants should understand:
 - What are the elements of a lean enterprise
 - How Lean supports Key Business Objectives
 - Strategy and Tactics of a Lean Transformation
 - Lean Methods and Tools

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☐ Today we are going to focus on the concepts and tools of Lean

Foundations: The Toyota Production System



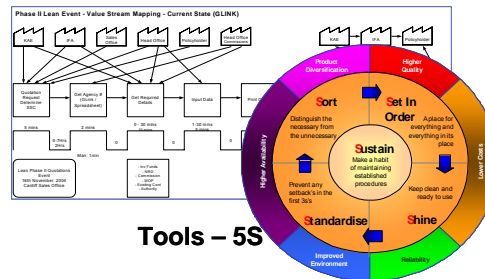
Five Principles of Lean



Eight Types Of Waste

Processing
Waiting
Motion
Inventory
Moving Things
Overproduction
Defects/Inspection
Intellect

Tools – Value Stream Mapping



Lean Consumption



☐ Origins of Lean

- Lean has been around a long time:
 - Pioneered by Ford in the early 1900's (33 hrs from iron ore to finished Model T, almost zero inventory but also zero flexibility!)
 - Perfected by Toyota post WWII (multiple models/colors/options, rapid setups, Kanban, mistake-proofing, almost zero inventory with maximum flexibility!)
- Known by many names:
 - Toyota Production System
 - Just-In-Time
 - Continuous Flow
- Typically based in manufacturing/production, but also highly applicable to transactional projects
- Outwardly focused on being flexible to meet customer demand, inwardly focused on reducing/eliminating the waste and cost in all processes

□ Using Lean Tools

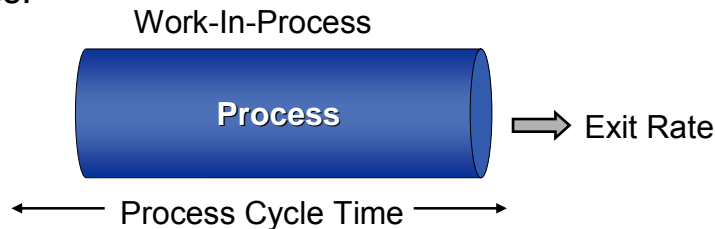
- The goal of “Lean” focused improvement projects is to increase the speed of a process
 - Controlling and reducing Cycle Time (and cycle time variability), will generate faster feedback cycles on improvement projects - increase process velocity and thus cycles of learning
 - In addition, controlling and reducing cycle time (and cycle time variability) is a key driver to:
 - Facilitating productivity improvements (reduced cost) and capacity improvements (increased revenue)
 - Remember: reducing cycle time shows us “where the rocks are!”
- Install workplace organization/visual systems
- Standardize & mistake-proof operations
- Redesign operations for steady flow
- Redesign operations from “push” to “pull”
- Rapid improvement via “*Kaizen events*”

☐ Using Lean Tools

Tool	Application		Expedia Six Sigma Training
	Process Improvement (Quality) Phase Applied (DMAIC)	Process Efficiency (Lean)	
Activity Network Diagram	Define, Analyze, Improve	√	Black Belt training
Affinity diagram	Define, Measure, Improve	√	Green Belt training, Champion training, Kaizen training, SOM-10
Benchmarking	Define, Improve	√	Green Belt training, Black Belt Training, Champion training, SOM-10
Brainstorming	Define, Measure, Analyze, Improve	√	Green Belt Training, Kaizen Training, SOM-10 Champion training
Control Charts (p, np, c, u, I, MR, Run, x-bar & R)	Analyze, Control	√	Green Belt Training, Black Belt Training, SOM-12 Champion training
Control Plans	Improve, Control	√	Green Belt Training, Black Belt Training, Champion training
Cost of Poor Quality - Concepts of Waste	Define, Measure, Analyze	√	Green Belt Training, Black Belt Training, SOM-5 Champion training
Current State Value Stream Mapping	Measure Analyze	√	Green Belt Training, Black Belt Training, SOM-7 Champion training, Kaizen training
Cycle Time Data Analysis	Analyze	√	Green Belt Training, Black Belt Training, SOM-11 Champion training
Five "S"	Define, Improve	√	Green Belt Training, Black Belt Training, SOM-12 Champion training, Kaizen training
Interrelationship Diagram	Define, Analyze, Improve	√	Black Belt training
Kaizen	Improve	√	Green Belt Training, Black Belt Training, SOM-12 Champion training
Kanban System	Improve	√	Black Belt Training
Matrix Diagram	Define, Analyze, Improve, Control	√	Green Belt Training, Black Belt Training, Champion training
Nominal Group Technique	Define, Deploy	√	Green Belt Training, Black Belt Training, SOM-10 Champion training
Poke-Yoke (Mistake Proofing)	Control	√	Green Belt Training, Black Belt Training Champion training
Prioritization Matrices	Define, Analyze, Improve	√	Green Belt Training, Black Belt Training, Champion training
Process Balancing (TAKT time)	Analyze Control	√	Green Belt Training, Black Belt Training, SOM-11 Champion training
Process Efficiency (PCE, PCT)	Analyze, Improve, Control	√	Green Belt Training, Black Belt Training, SOM-11 Champion training
Process Mapping	Define, Improve	√	Green Belt Training, Black Belt Training, SOM-2 Champion training
Throughput Yield (First time and rolled)		√	Green Belt Training, Black Belt Training, Kaizen Training, Champion training
Tree Diagrams	Define, Measure	√	Green Belt Training, Black Belt Training, SOM-8 Champion training
Value Added/ Non-Value Added Analysis	Analyze	√	Green Belt Training, Black Belt Training, SOM-7 Champion training
Value Stream Mapping - Future State	Improve	√	Green Belt Training, Black Belt Training, SOM-7 Champion training
Visual Management	Measure Control	√	Green Belt Training, Black Belt Training, SOM-12 Champion training
WIP Cap	Analyze Improve	√	Green Belt Training, Black Belt Training, SOM-11 Champion training
Failure Modes and Effect Analysis (FMEA)	Measure, Analyze, Improve	√	Green Belt Training, Black Belt Training, SOM-9 Champion training
Histograms	Analyze	√	Green Belt Training, Black Belt Training, SOM-6 Champion training
Pareto Charts	Define, Analyze, Improve, Control	√	Green Belt Training, Black Belt Training, SOM-6 Champion training

□ Key Lean Definitions

- The following definitions are used throughout Lean Six Sigma discussions to describe the speed, efficiency, throughput, and capacity of a process:



- Process Cycle Time (PCT):** The time from release of a product into a process until its completion
 - Example: The elapsed time from when a customer calls, to when the ticket is issued averages 3 days
- Work-In-Process (WIP):** Product that is within the boundaries of the process
 - Example: There were 3300 reservation applications in process at the end of the month
- Exit Rate (Throughput):** The output of a process over a defined period of time
 - Example: Our process closed 500 reservation applications per day last month
- Capacity:** The maximum amount of service a process can deliver over a continuous period of time
 - Example: The capacity of our process is 120 reservations per hour
- Time Trap:** Any process step that inserts delay time into a process
 - We are concerned with the time trap that injects the MOST delay
 - Example: our quality team evaluate 120 transactions per day, all other process steps can process 145 transactions per day
- Constraint:** A time trap that is unable to produce at the exit rate required to meet customer demand (internal or external)
 - Example: our agents can only complete 120 reservations per day, but customer demand is currently 130 reservations per day!

☐ **The Basics of Lean**

1. Determine the Voice of the Customer (VOC)
2. Identify the Process Value Stream
3. Implement Pull Systems
4. Improve Process Flow
5. Achieve Lean Perfection – Continuous Improvement

Lean Goals

Highest Quality, Lowest Cost, Shortest Time, Maximum Flexibility

☐ **1. Determine the Voice of the Customer**

- The challenge is to understand how your customers define and prioritize the various needs and expectations they have of your products and services

Quality

Product or Service Features, Attributes, Dimensions, Characteristics Relating to the Function of the Product or Service, Reliability, Availability, Taste, Effectiveness - Also Freedom from Defects, Rework or Scrap

Cost

Prices to Consumer (Initial Plus Life Cycle), Repair Costs, Purchase Price, Financing Terms, Depreciation, Residual Value

Delivery

Lead Times, Delivery Times, Turnaround Times, Setup Times, Cycle Times, Delays

Service & Safety

Service Requirements, After-Purchase Reliability, Parts Availability, Service, Warranties, Maintainability, Customer-Required Maintenance, Product Liability, Product/Service Safety

Corporate Responsibility

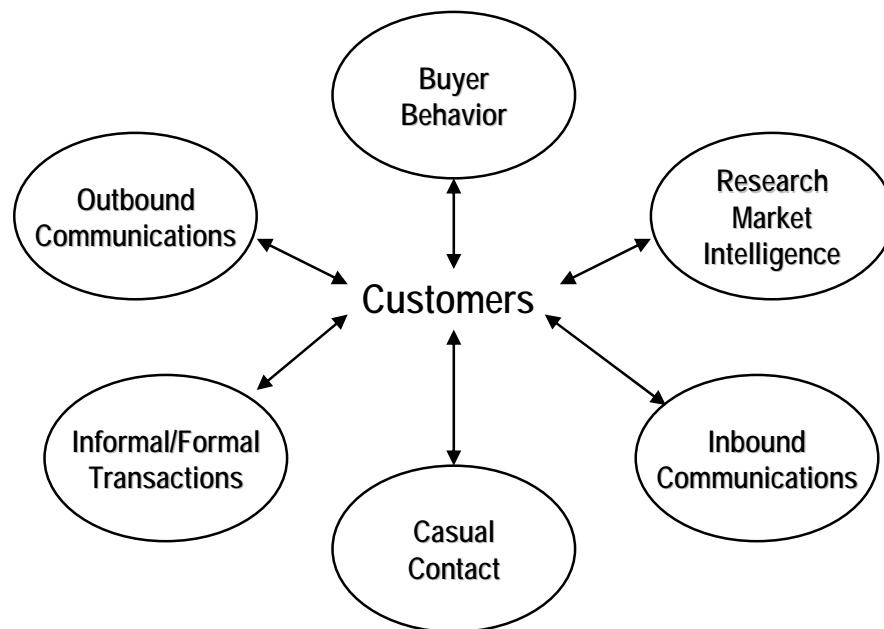
Ethical Business Conduct, Environmental Impact, Business Risk Management, Regulatory and Legal Compliance

☐ 1. Determine the Voice of the Customer

Types of Voices

- Complaints
- Compliments
- Product returns
- Product/service sales preferences
- Contract cancellations
- Market share changes
- Customer defections/acquisitions
- Customer referrals
- Closure rates of sales calls
- What other customer voices could you or do you use in your business

How do our customers communicate to us?

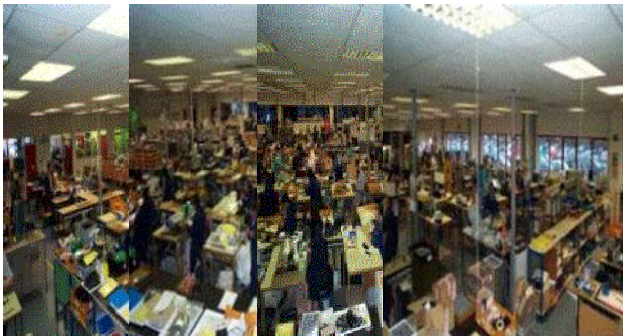


□ 2. Identify the Value Stream

- Process mapping is a lean technique first used by Toyota

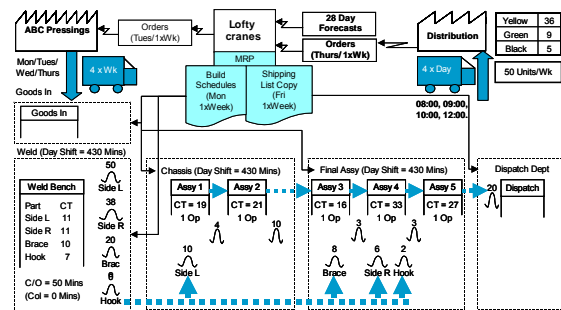
Taichi Ohno's problem

- Managed a machine shop
- Had a large area of responsibility
- Had an unsatisfied customer
- Could not see non-value add or flow at a glance



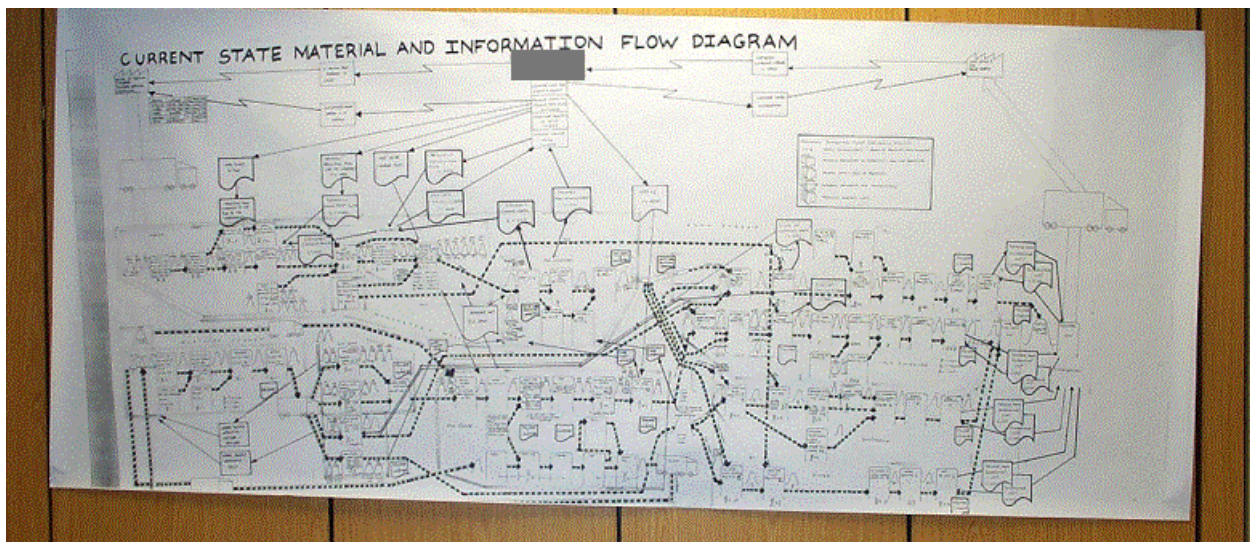
The solution

A standard method for flow mapping



□ Purpose of Process Mapping

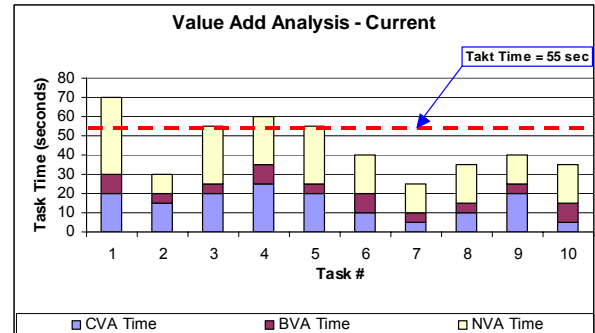
- Identify problems and opportunities in the current process
- Develop and communicate what the target end state should look like and how to get there?



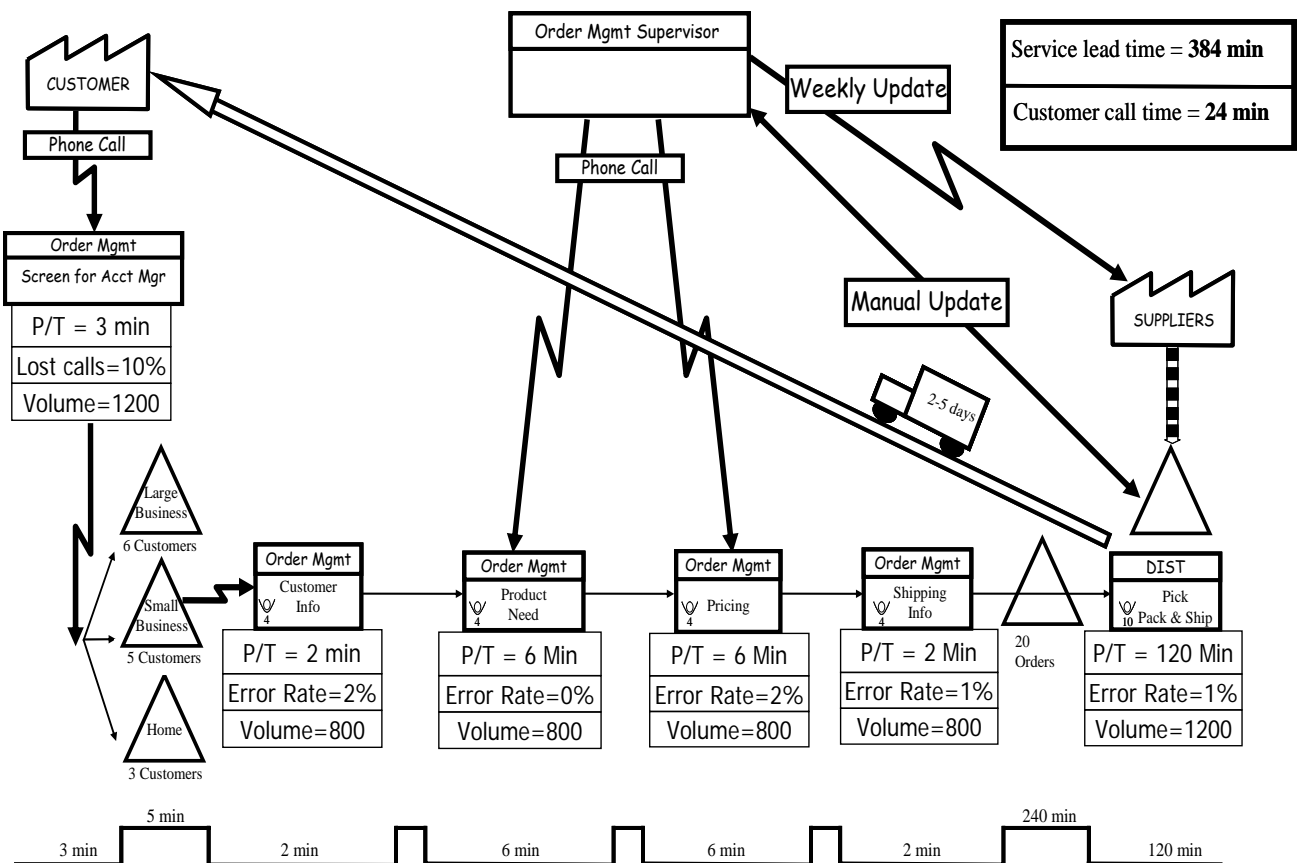
□ Value Stream Mapping

- The value stream is all of the operations/activities that are necessary to bring a specific product through critical business tasks:

- Problem solving
- Information management
- Physical transformation
- Delivery to customer



- Define Value Add along the Value Stream
 - What adds value to product (function, form, or feature)
 - What destroys value for the business (8 types of waste)



□ Two Stages of Value Stream Mapping

- **Current State**

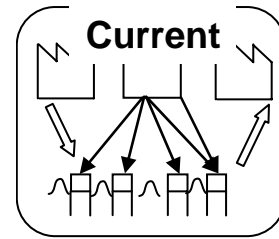
- Rigorous, fact based analysis

- **Purpose**

- Detailed visual description of the current value stream

- **Objectives**

- Show a holistic view of the entire current system
- Visualize material and information interactions
- Highlight non-value add and its sources throughout the system
- Identify problems and improvement ideas
- Provide common framework for discussion



- **Future State**

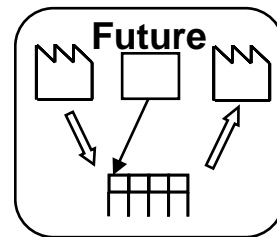
- Creative design synthesis

- **Purpose**

- Detailed visual description of a redesigned best practice value stream

- **Objectives**

- Force best practice in creating a vision of the ideal lean value stream
- Set baseline for tactical implementation planning by identifying value stream loops
- Prioritize improvement efforts/actions
- Assist in quantifying improvement potential
- Allow target setting (short-mid-long term)



☐ Example of Key Process Data

Measurement	Description
Product variations	Number of distinct types of loans or applications in each process step
Cycle time (C/T)	Time elapsing between 1 completed loan and the next completed loan (includes wait time)
Wait time (Wait)	Time spent by the loan in a queue
Touch time (T/T)	Time spent actually processing the loan (i.e., the time an operator actually touches the loan or file)
Setup time (S/T)	Time spent prior to beginning process per FTE per shift (e.g., login time)
Working time (W/T)	Maximum theoretical time per FTE per shift available for each step (minus break, meeting, and clean up) in hours
Uptime	Actual amount of time available to process loans per FTE per shift (hours)
Number of FTEs	People available to fully operate a process step per shift
Number of shifts	Number of shifts per day
Error rate	Percent of applications or loan packages subject to rework as a result of the selected area
Inventory/Queue size	Number of applications or loan packages waiting for next process step
Distance traveled* (D/T)	Distance for manual transfer of paperwork
Capacity	Maximum number of loans processed per hour per person/machine (e.g., fax or scanner)

☐ **Lean Mission Statement**

Develop the Ability:

- To understand that waste simply:
 - Raises cost
 - Produces no corresponding benefit
 - Threatens all of our jobs
- To recognize and identify waste
- To have the courage to call it waste
- To have the desire to eliminate waste
- To apply tools/techniques to eliminate waste
- To understand the benefits of eliminating waste
 - External (customer satisfaction, shareholder value)
 - Internal (employee satisfaction, financial improvement)

☐ **Lean Focuses on Eliminating the Eight types of Waste or Non-Value Added activities**

- Eight Categories of Waste
 1. **Overproduction** above demand
 2. **Waiting** for processing, use, work
 3. **Transport** of products/materials
 4. **Over-processing**
 5. **Inventory**
 6. **Unnecessary motion**
 7. **Defective** parts/products
 8. **Intellectual Waste**



The Eight Wastes are inherent in EVERY process – the key is the methodology, tools, and techniques to reduce and eliminate them!

☐ **Waste... According to Webster**

- Material left over, rejected or thrown away
- Refuse that accumulates about habitations
- Being wild and uninhabited
- To spend money or use property carelessly (syn. squander)

☐ **Waste...According to Customers**

- Something that consumes resources but **adds no value** to a product or service
 - Value is defined by the customer
- **“Non-value-added”**

☐ **The Opposite of Waste: “Value-Added”**

- Any activity which changes a product or service in a way that enhances value from a **customer’s perspective**

“The ability to eliminate waste is developed by giving up the belief that there is ‘no other way’ to perform a given task. It is useless to say, ‘It has to be done that way,’ or ‘This can’t be helped!’

***At Toyota, we have found that
there is always another way.”***

– Study of the Toyota Production System

☐ Why Focus on Waste?

- Because most processes are 95–99% non-value-added, a focus on minimizing waste is the best leverage for an improvement effort

NVA	95%	VA 5%
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☐ Overproduction

- Making more than required by next process
- Making earlier than required by next process
- Making faster than required by next process
- Causes of overproduction
 - Just-in-case logic
 - Misuse of automation
 - Long process set-up
 - Unleveled scheduling
 - Unbalanced work load
 - Over engineered
 - Redundant inspections



☐ **Waiting Waste**

- Idle time created when waiting for processing, use, work...
 - Unbalanced work load
 - Unplanned maintenance
 - Misuses of automation
 - Upstream quality problems
 - Uneveled scheduling
- **Examples**
 - Signing documents
 - Batch Processing



☐ **Transport Waste**

- Transporting parts and materials around the facility
 - Poor facility layout
 - On-line approvals
 - E-mail forwarding
- **Examples**
 - Walking information to post room / Scanning / Legal
 - Handoffs



☐ **Over Processing Waste**

- Effort that adds no value to the product or service from the customer's viewpoint
 - Product changes without process changes
 - Just-in-case logic
 - True customer requirements undefined
 - Over processing to accommodate downtime Lack of communications
 - Redundant approvals
 - Extra copies/excessive information
- **Examples**
 - Duplicate Vetting Processes
 - Producing more than customer demands- Marketing Literature



□ Inventory Waste

- Any queuing/supply in excess of a single demand flow through the process
 - Excess forms, completed customer applications
 - Excess inventory
 - Protect company from unexpected problems
 - Uneveled scheduling
 - Poor market forecast
 - Unbalanced workloads
 - Unreliable shipment by suppliers
 - Reward system
- **Examples**
 - Storing items uses valuable floor space
 - Unnecessary stocks of marketing literature/ Brochures



☐ **Unnecessary Motion Waste**

- Any movement of people or machines that does not add value to the product or service
 - Poor effectiveness of people/machine interface
 - Inconsistent work methods
 - Unfavorable facility or work area/cell layout
 - Poor workplace organization and housekeeping
 - Extra “busy” movements while waiting
- **Examples**
 - Check signing process
 - Looking for missing files/ Information



☐ **Defective Parts/Products Waste**

- Inspection, rework, repair of materials, parts or products; review, rework/redo of service activities
 - Weak process control
 - Poor quality
 - Incapable processes
 - Product/process design
 - Inadequate education, training, work instructions
 - Customer needs/requirements not understood
 - First call resolution
- Defects cause waste in the form of unnecessary inspection, rework and repair

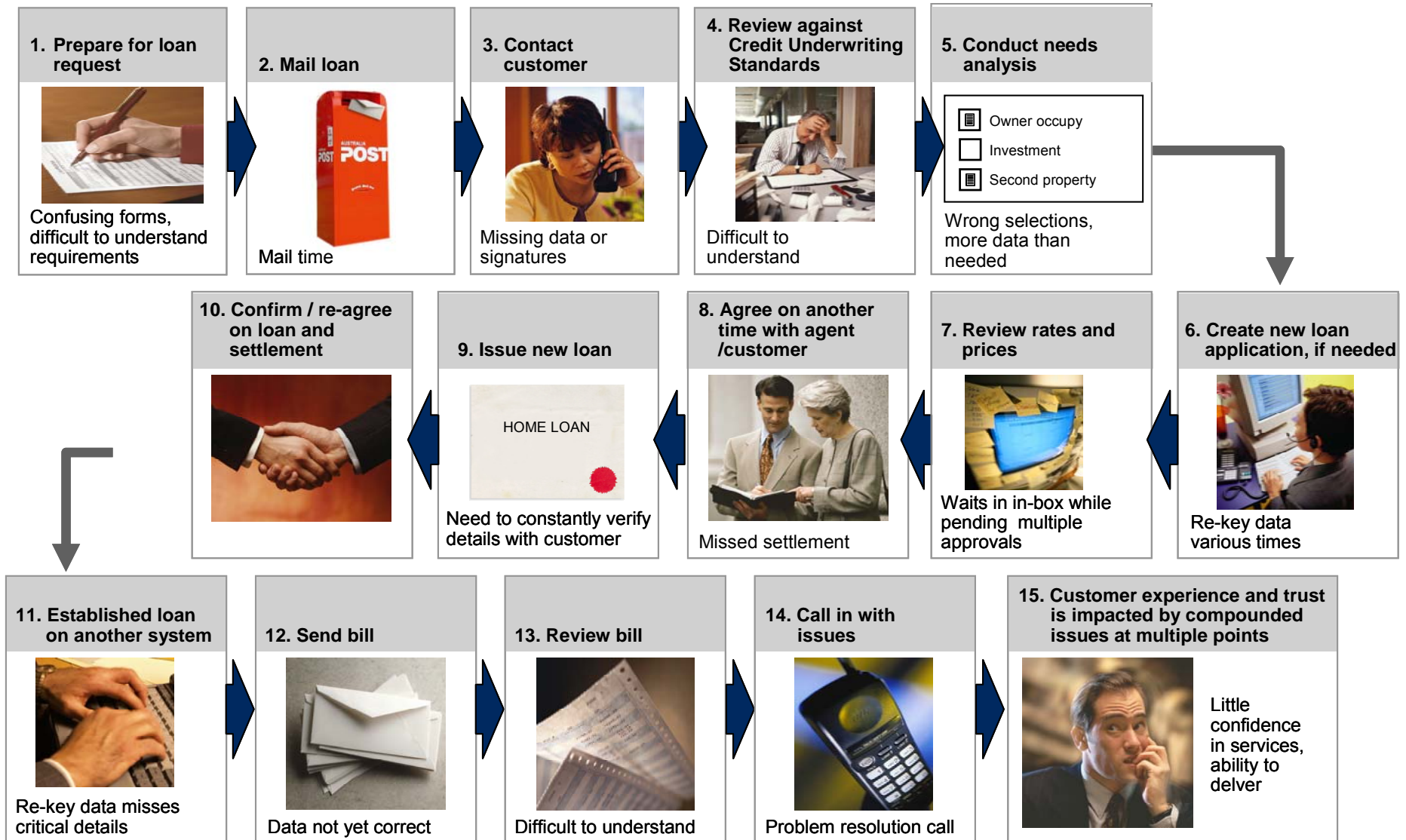


☐ Human Intellect Waste

- Misuse of skill level
- Lack of training; for the job at hand, job progression, and to provide opportunities for more creative thinking
- Not listening to employees ideas who are involved first hand in the actual work
- Not incorporating front line workers in the process of new product design
- Not acting on employee complaints about legitimate problems and solutions



□ Example of Waste in your home loan process



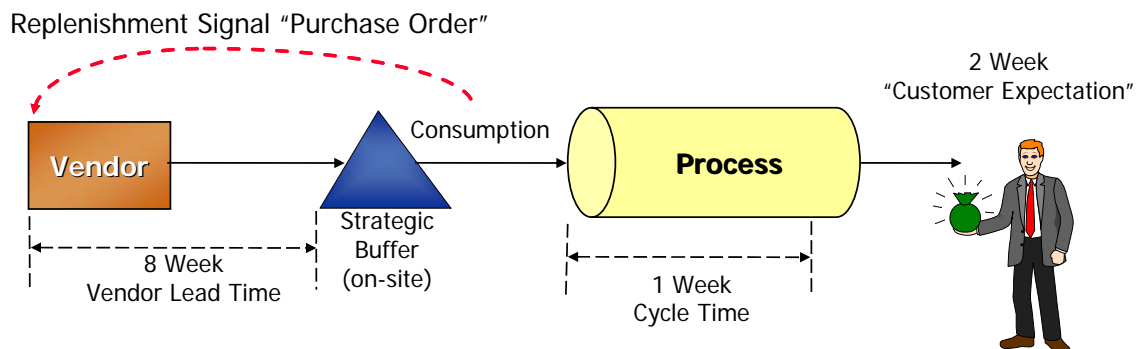
☐ Example Data Collection Sheet

Start time: _____	End time: _____
Distance from last queue (if applicable): _____	
Process step: _____	
Activity	Number of FTEs
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
Touch time (minutes): _____	
Size of batch (no. of applications or reservations): _____	
Product mix in batch (percent): _____	

Distance to next step/queue (feet): _____	
Next queue wait time (minutes): _____	

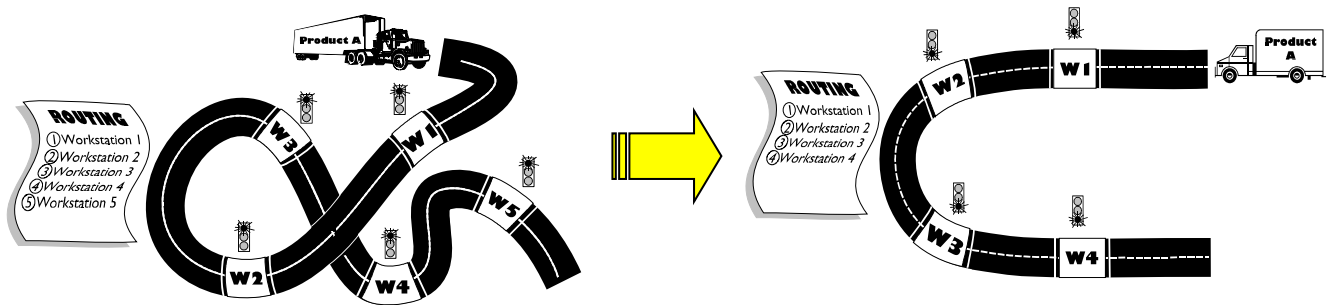
☐ 3. Implement Pull Systems

- Pull means that **real** customer demand pulls products through the system
 - Excess Inventory is waste
 - Producing items that are not needed is waste (forecast)
- Part shortages and expediting reduced or eliminated
- Inventory reduced (better mix)

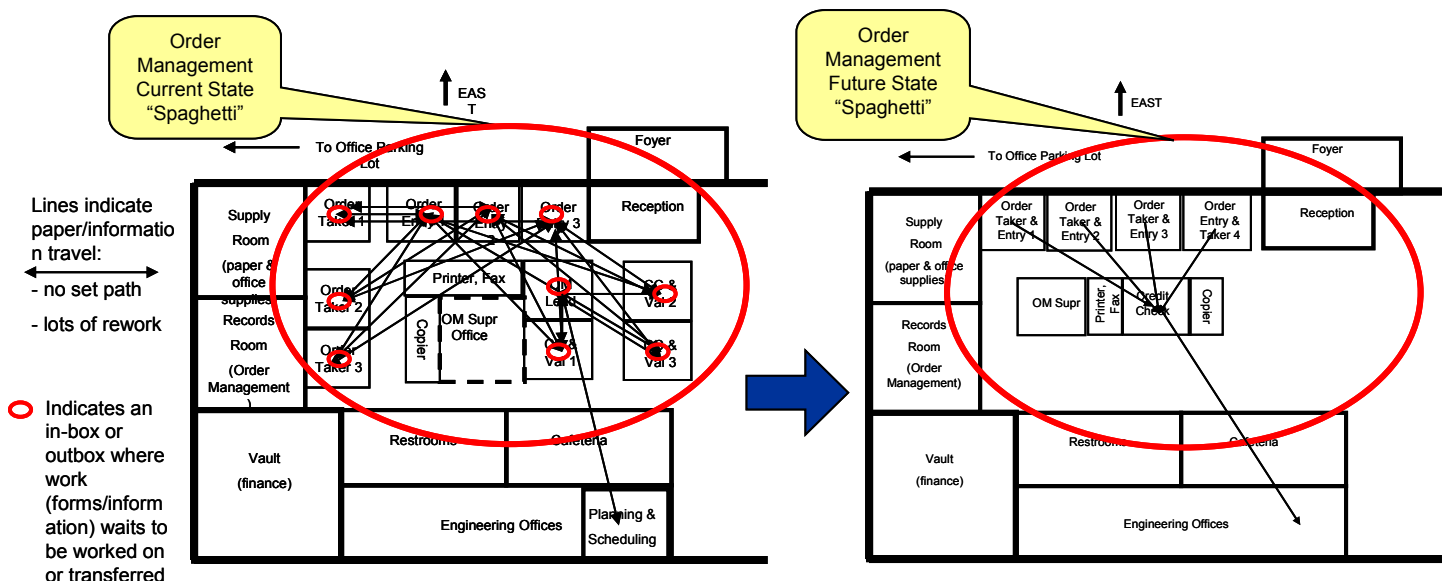


4. Improve Process Flow

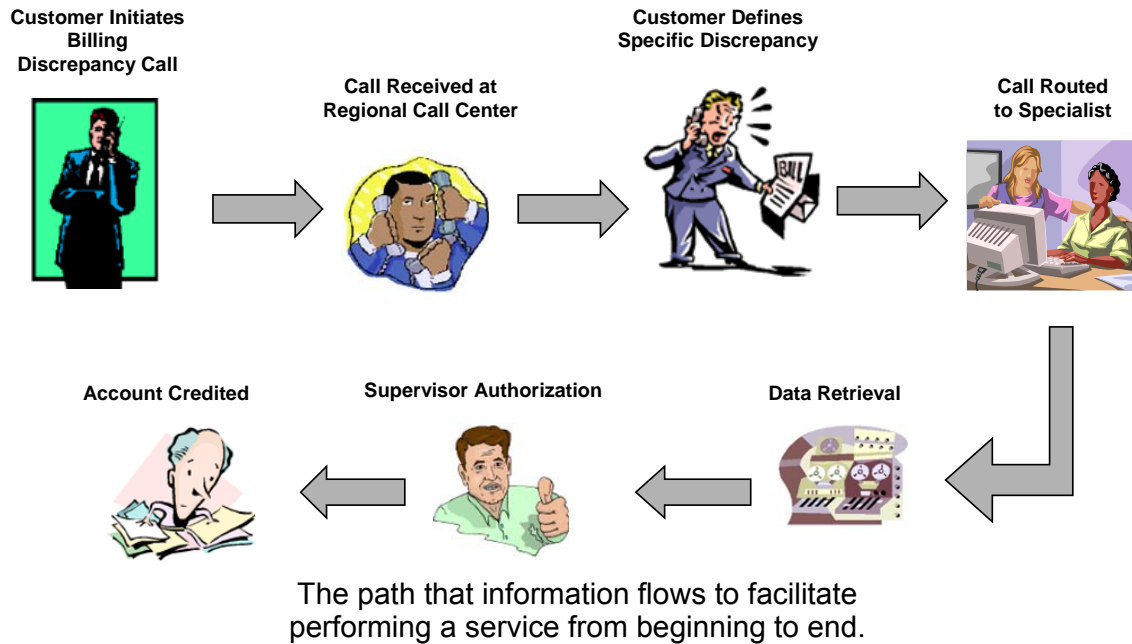
- Process Flow is the distance that a product must travel and the time it takes to be completed
 - Process flow improvement seeks to eliminate waste due to:
 - Excess motion
 - Transportation
 - Waiting
 - By moving resources closer together and eliminating non-value added time, movement, waiting, etc.



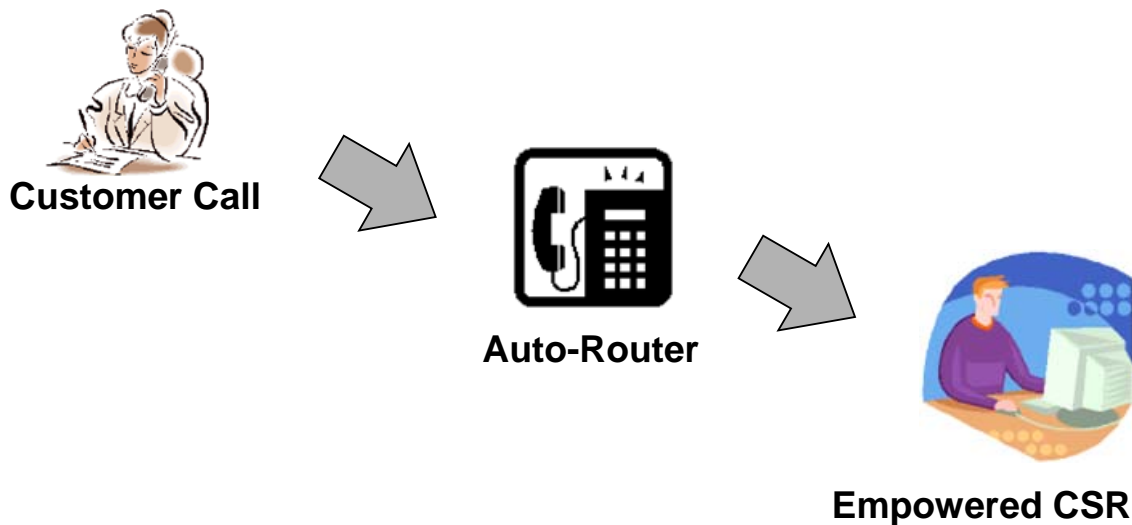
- The goal is to reduce handoffs and have the service or information travel as little as possible to minimize the customer wait time
 - Co-Locate Personnel
 - Focused / High Performance Work Area
 - Minimize Handoffs



□ Process Flow



• Improvement

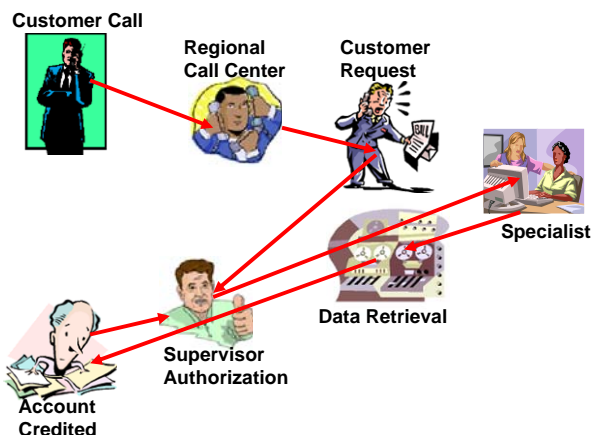


Definition: Simplifying the process flow by reducing the time needed to complete the service and eliminate opportunity for mistakes (through process simplification and co-location)

□ Traditional Process Flow (Functional Departments)

Traditional Characteristics:

- Resources arranged in distinct functional departments
- Departments can often be in different buildings, locations or even states
- Employees dedicated to a department and a position/workstation
- Specialized knowledge “These are the screens I use”
- Departments arranged by “space required” over time, no particular flow
- Batch processing
- No visibility to the whole process, nor knowledge of a broader process (very myopic)
- Poor metrics for total process performance
- If metrics even exist, they are at the task level, leading to sub-optimization of whole process

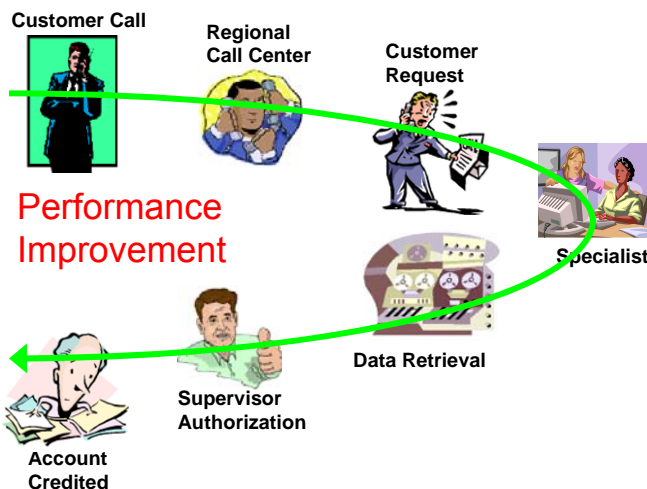


Traditional process flow through functional departments that are typically not located “next” to one another, many handoffs and decision points that may or may not be necessary, all leading to long wait/processing times

☐ Process Flow Improvement (Co-Location, Case Teams, Cells)

Cell Characteristics:

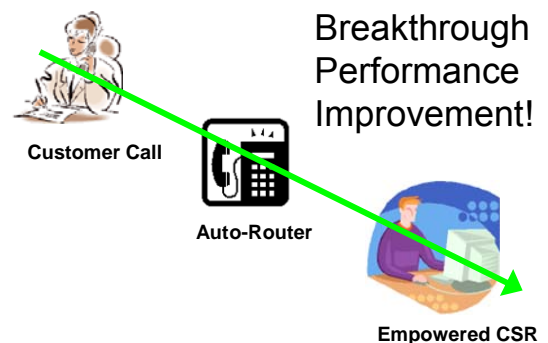
- Unneeded (non-value-add) steps removed
- Value-added steps simplified
- Resource layout follows 'whole' process sequence
- Co-located, cellular layouts (case teams)
- Multi-capable employees (can do multiple jobs) creating a flexible workforce
- One-piece flow processing (pull signals)
- Remove Authorization Barriers
- Processing paced to customer demand rate (Takt Rate)
- Standard operations defined



Performance Improvement

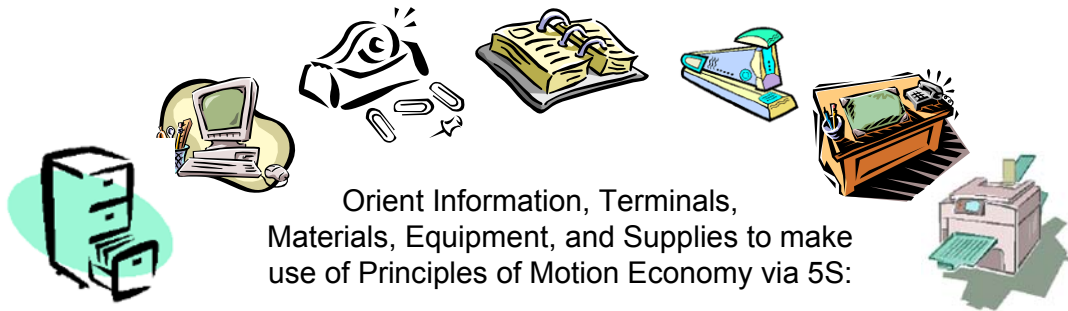
Simplifying the process flow by reducing the time needed to complete the service and eliminate opportunity for mistakes.

This can be done physically (performance improvement) or electronically (breakthrough performance improvement!)



Breakthrough Performance Improvement!

☐ Create Focused Work Space



- Principle 1 – Keep trunk motions to a minimum
- Principle 2 – Use gravity instead of muscle whenever possible
- Principle 3 – Avoid zigzagging motions and quick direction changes
- Principle 4 – Move with steady rhythms
- Principle 5 – Keeps materials/supplies close and in front
- Principle 6 – Arrange material and tools in order of use
- Principle 7 – Work at the proper ergonomic height
- Principle 8 – Locate materials so they are easy to lift
- Principle 9 – Place keyboards at correct height and use ergo-typing aids

☐ Process Flow Improvement in Transactional Processes (Example)



Enablers of the Process Improvement

- Collocation of Necessary (cross-functional) Skill Sets
- 34" Walls Eliminate Transportation of Information
- Management Layers Decreased from 8 to 3
- Easily Identifiable Process Owners
- Central Tables Facilitate Rapid Learning Cycles



Benefits

- 50-90% Reduction in the Order Fulfillment Cycle Time
- Immediate, Informal Cross-Training
- Better Morale & Teamwork
- Faster, Seamless Flow of Information
- Rapid Response Problem Solving
- Single Point of Contact for Customer

☐ Other Improvement Examples

- Simplification / Elimination of forms
- Eliminate multiple entry of same data
 - I.e., only enter account number one time, carries through to all account fields
- Drop down lists to eliminate errors
- Single key/field entry to other screens: do not need to back out of long tree
 - How to quickly get back to page 4 when on page 10?
- Work all jobs FIFO, or work small/easy jobs first?
- Set aside capacity for certain customers?
 - 10 item or less check-out counters
 - Doctor sees patients Mon, Tue, performs surgery Wed, Thur

☐ 5. Achieve Lean Perfection

Lean Definition:

“A manufacturing strategy that uses less of everything compared with traditional manufacturing: half the human effort, half the space, half the investment in tools, half the engineering hours to develop a new product. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects and produces a greater and ever growing variety of products.”

“The goal of lean manufacturing is perfection: continually declining cost, zero defects, zero inventories, and endless product variety.”

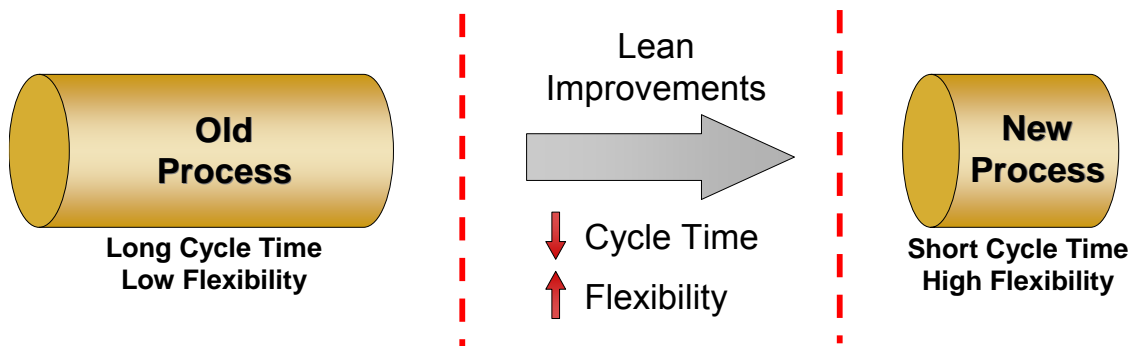
– The Machine That Changed the World

☐ 5. Achieve Lean Perfection

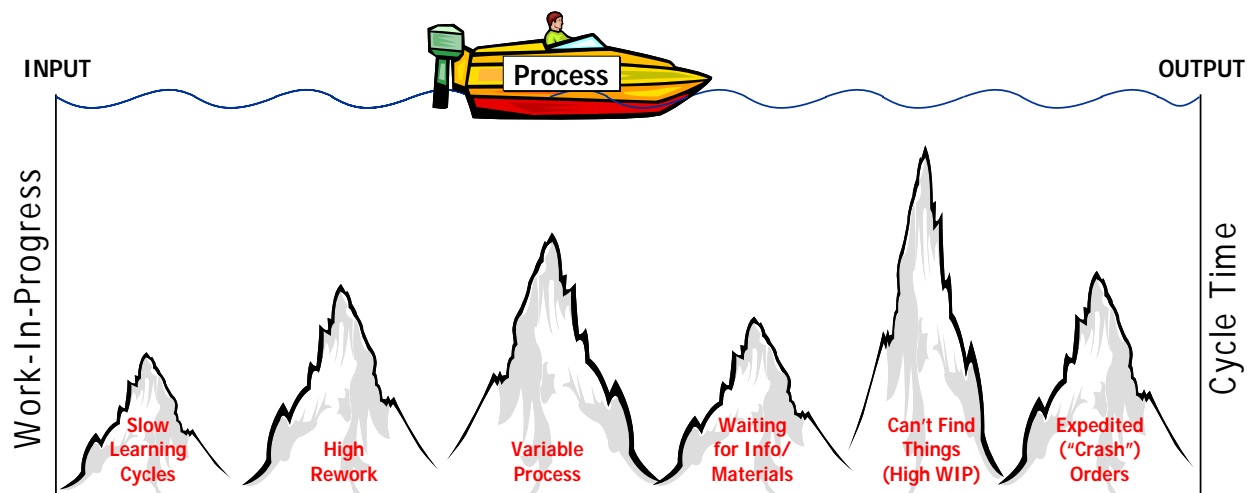
- Identify all opportunities for continuous improvement
 - Reduction of effort
 - Reduction of time
 - Reduction of space
 - Reduction of cost
 - Reduction of mistakes
 - Increasing customer satisfaction
- Improve the process through a variety of Lean tools/techniques:
 - Value Stream Mapping
 - Time Trap Identification
 - Heijunka/Leveling/Stability (S&OP)
 - Kaizen/Continuous Improvement
 - Kaikaku/Innovation
 - Jidoka/Automation
 - Kanban/Just In Time
 - 5S Organization
 - Stocking Strategy
 - Generic & Replenishment Pull Systems
 - Visual Tools, Visual Processes
 - Cellular Layouts & Line Balancing
 - Standardized Work
 - Total Productive Maintenance (TPM)
 - Make vs. Buy, Distribution Mgmt,
 - Strategic Sourcing, Tactical Purchasing

☐ 5. Achieve Lean Perfection

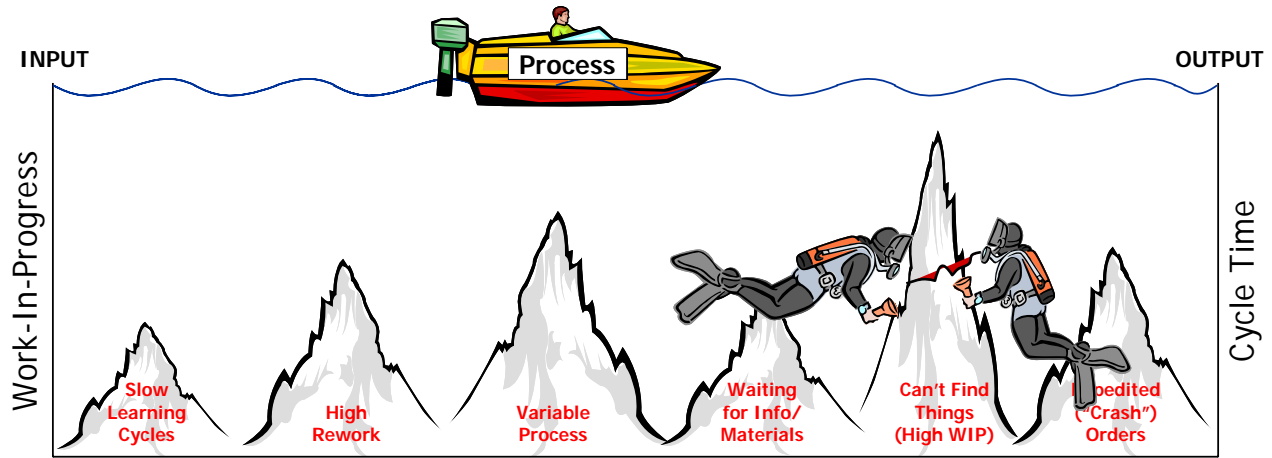
- Faster feedback on process performance (increased learning cycles)
- Improved first pass yield (results in improved productivity)
- Improved process stability (results in improved throughput)
- Uncovers process deficiencies (forces problem resolution)
- Less in-process and buffer inventories (reduced risk)
- Improved customer satisfaction (flexibility and responsiveness)



☐ Traditional Processes: Lots of Stuff in Process = Long Cycle Times

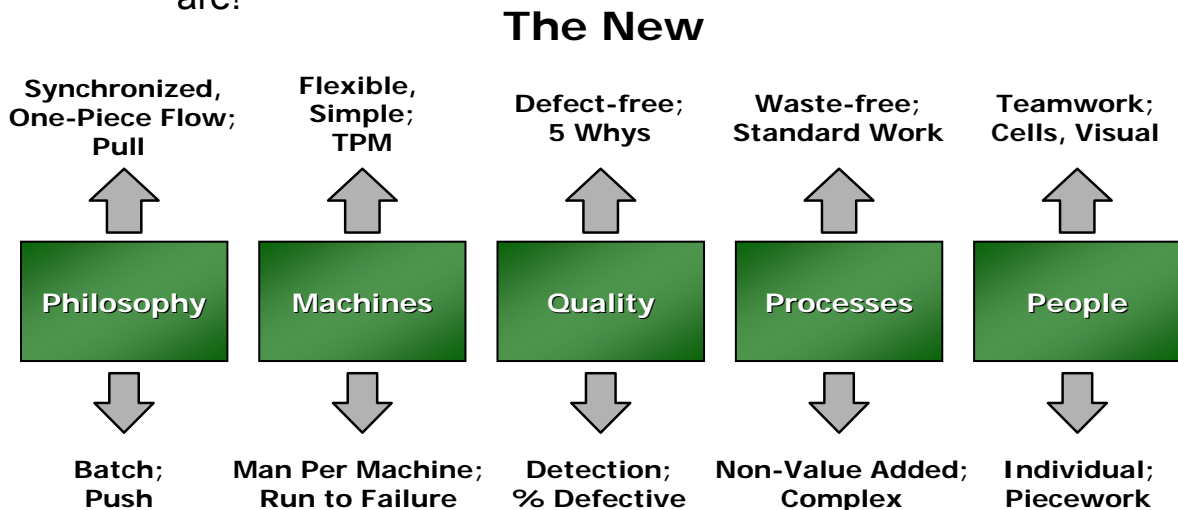


☐ Lean Processes: Time Trap Resolution Reduces WIP & PCT



☐ The Value of Cycle Time: What Is Our Goal?

- The goal of Lean Improvement projects is to increase the speed of a process
 - Controlling and reducing Cycle Time (and cycle time variability), will generate faster feedback cycles on improvement projects - increase process velocity and thus cycles of learning
 - In addition, controlling and reducing cycle time (and cycle time variability) is a key driver to:
 - Facilitating productivity improvements (reduced cost) and capacity improvements (increased revenue)
 - Remember: reducing cycle time shows us “where the rocks are!”



□ Little's Law

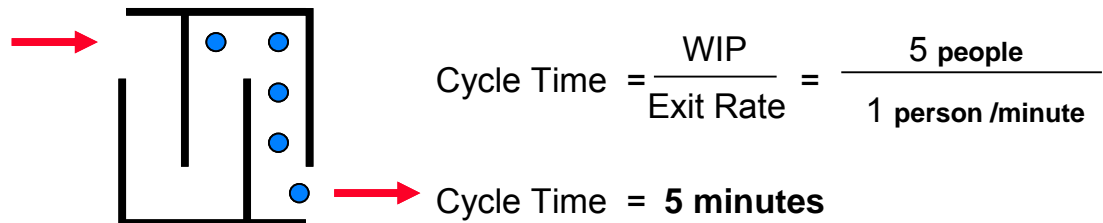
- Little's Law describes the relationship between WIP, PCT, and Throughput:

$$PCT = \frac{WIP}{EXIT\ RATE}$$

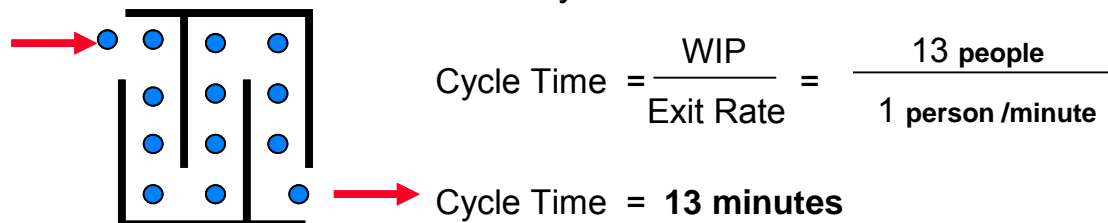
- This is the most fundamental relationship for any process -
 - The “F = MA” (Force = Mass x Acceleration – accepted law of physics) for processes
- Used to size number of people, paperwork, projects – any process!
- Lower Process Cycle Time = More “Learning Cycles” (Learning Cycle = number of instances to learn about the process)

□ Cycle Time = WIP / Exit Rate: “Disney Land...”

- Think about the lines at Disneyland in March...



- ...and then think about them in July...



- ...Conclusion: Fixed Capacity (Exit Rate) + Increased People (WIP) = Slower Cycle Times (PCT)!

□ **Process Cycle Efficiency (PCE)**

- PCE is a measure of the relative efficiency in a process - it represents the percentage of value add time (changing form, fit, function) of a product down the critical path
- It is calculated using:

$$\text{Process Cycle Efficiency} = \frac{\text{Customer Value Add Time}}{\text{Process Cycle Time}}$$

- PCE is the performance indicator of how efficiently the process is converting work-in-process into exits

World Class Cycle Efficiency Benchmarks*

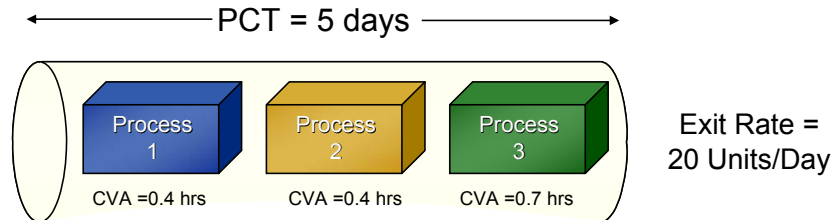
Application	Low-End PCE Goal	High-End PCE Goal (World-Class PCE)
Creative/Cognitive Processes	5%	25%
Transactional Processes	10%	50%
Batch Transfer Assembly	15%	35%
Continuous/One Piece Flow Assembly	30%	80%

* Based on data from over 100 companies

- **Rules of Thumb:**
 - If current PCE is << Low End Target, multiply current PCE by 10 (one order of magnitude improvement) for use as Target to be conservative
 - If current PCE is < Low End Target, use Low End as Target PCE
 - If current PCE \cong or > Low End Target, use High End as Target PCE

□ Calculating PCE *Example:*

- What is the Process Cycle Efficiency for the process below?



WIP = Sum of All Work Within Physical Work Area = 100 Units

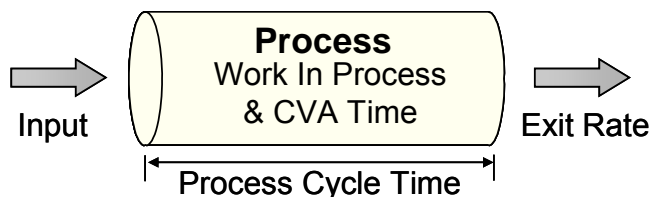
Our Example PCE is:

$$\text{PCE} = \text{CVA Time} / \text{PCT}$$

$$\text{PCE} = 1.5 \text{ hrs} / 5 \text{ days}$$

$$\text{PCE} = 4.0\% \text{ (assume 7.5 hrs/day)}$$

□ PCT and PCE



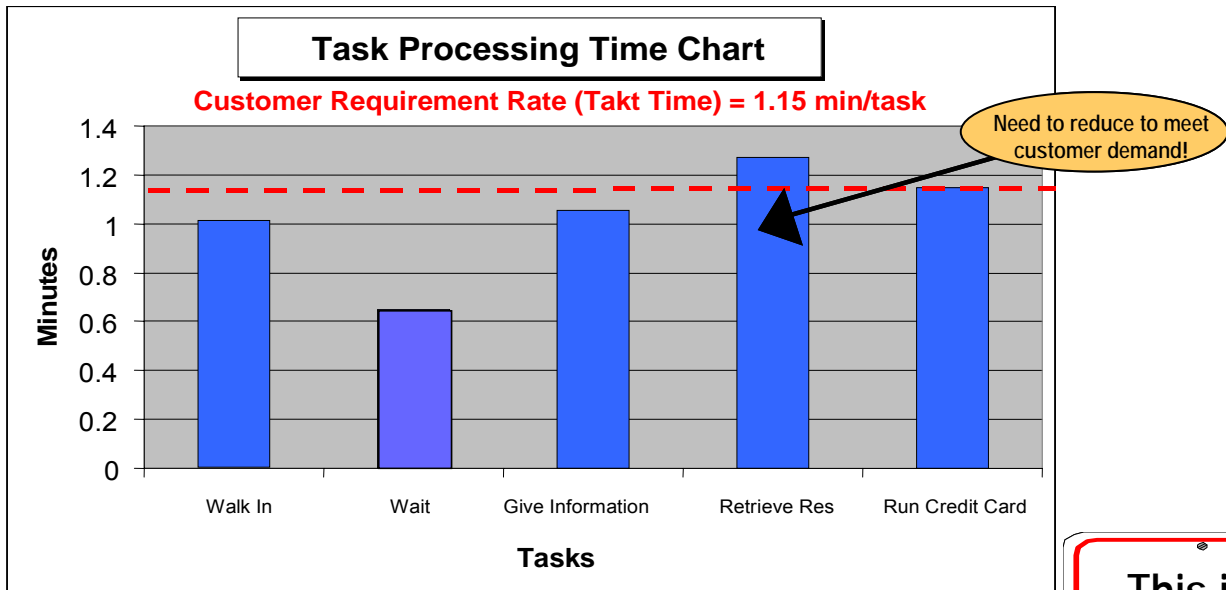
$$\text{PCT} = \text{WIP} / \text{Exit Rate}$$

$$\text{PCE} = \text{CVA Time} / \text{PCT}$$

Recall that:

- **Work-In-Process (WIP)** = “Things in Process” – Customer Orders, People In Queue, Documents, etc.
- **Exit Rate** = The output of a process, expressed in units/time (equal to the rate of the time trap (constraint) operation)
- **Process Cycle Time (PCT)** = the time from release of a product into a process until it is completed
- **Customer Value Add Time (CVA Time)** = the amount of time that value is actually being added to a product (the time that the customer is willing to pay for)

☐ Identifying the Bottleneck and/or Constraint



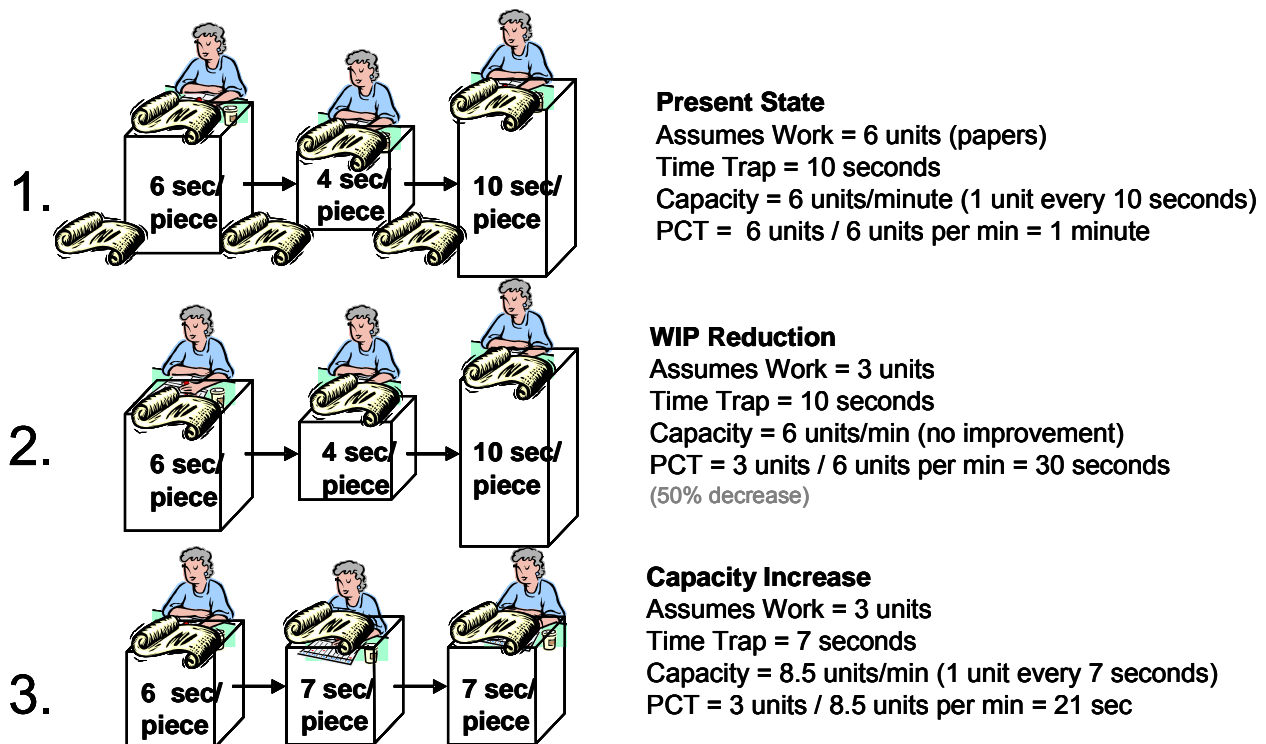
This is a
Time Trap!!

☐ What Is a Time Trap?

- A time trap limits the output of the process and therefore has less capacity than the prior or following steps
 - It limits throughput
- A time trap can change over time (monthly, weekly, even daily) based upon “service” mixes or special causes (new service introductions, special orders/requests)
- A time trap can be caused by physical problems (such as process flow, personnel availability, mistakes, etc.)
- A time trap can also be caused by non-physical problems (such as procedures, morale, unsafe environment, or training)
- There is ALWAYS a time trap in a process!
- A **constraint** is a time trap that cannot meet customer demand (a constraint is ALWAYS a time trap, but a time trap may not be a constraint!)

☐ Time Traps: Cycle Time \neq Capacity

- The Time Trap determines the Capacity of the process, however, Capacity does not have a direct (one-to-one) relation to Cycle Time:
 - Process Cycle Time = $WIP / \text{Exit Rate} \neq \text{Capacity}$: A reduction in cycle time does not directly yield an increase in capacity (i.e., exit rate)
 - An increase in capacity is obtained by decreasing the **process** (“touch”) time of the time trap

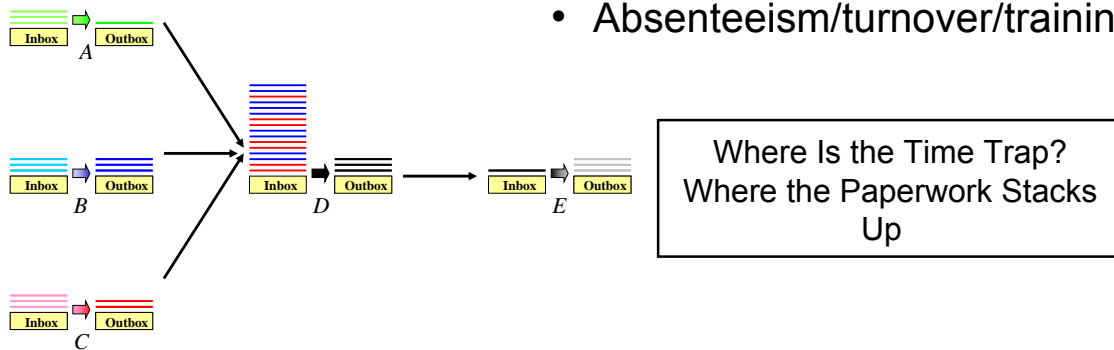


☐ Cycle Time Effect on Capacity

- Cycle time can indirectly influence throughput (and thus capacity) by:
 - Increasing productivity:
 - Less search, moving, working around work in process
 - Decrease rework & lost work:
 - Catch mistakes quicker
 - Discover lost work faster

□ How Are Time Traps Created?

- Poor process flow
- Lack of service/information
- Movement of service/information
- Handoffs
- Setups
- Quality issues/rework
- Resource uptime (computers, networks)
- Variability
- Process complexity
- Stress
- Absenteeism/turnover/training



□ Takt Rate Analysis

- **Time Trap Identification** – the process (or process step) that injects the most amount of delay into the process is the time trap
- Takt Rate Analysis compares the task time of each process (or process step) to:
 - Each other to determine the time trap
 - Customer demand to determine if the time trap is the constraint

$$\text{Takt Rate} = \text{Customer Demand Rate} = \frac{\text{Number of Units to Process}}{\text{Net Process Time Available}}$$

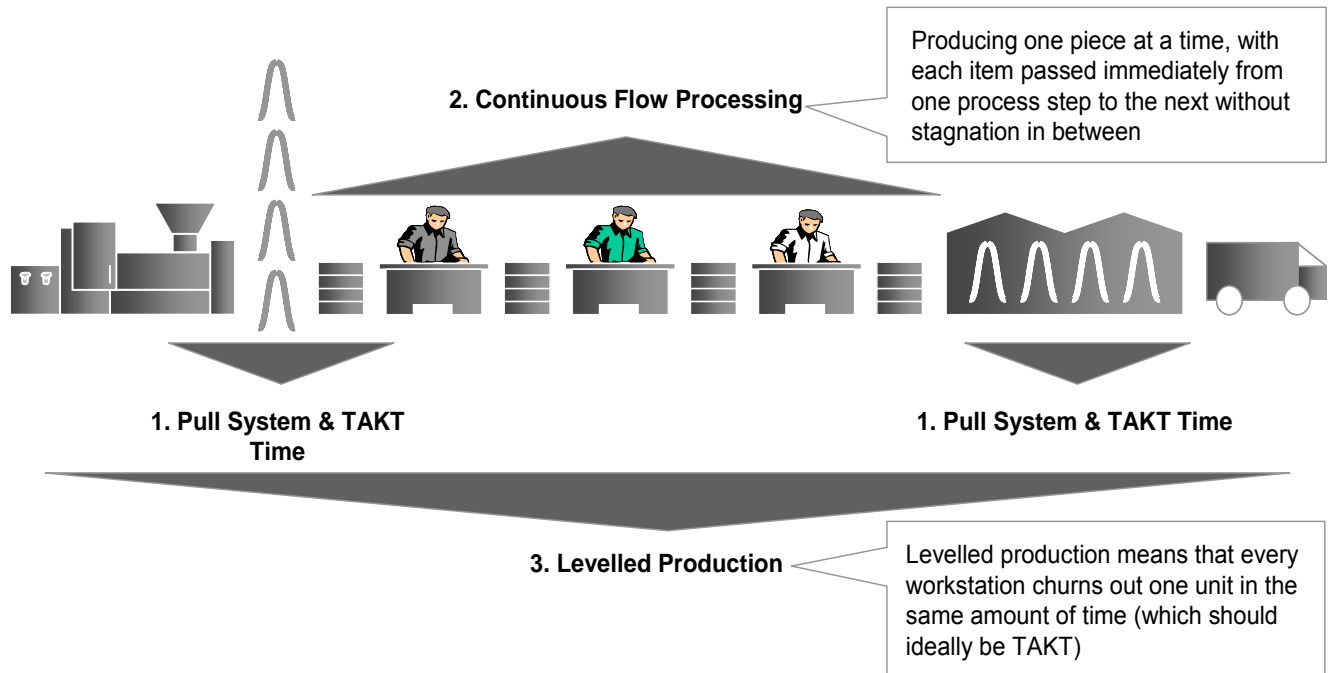
$$\text{Takt Time} = \frac{\text{Net Process Time Available}}{\text{Number of Units to Process}}$$



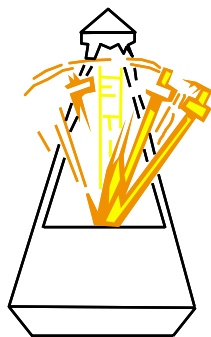
Example: Traveler demand for reservations is 24,000 tickets per month. The net process time available is 30 days per month. The Takt Rate is: 24,000 tickets / 30 days per month = 800 tickets/day

□ Takt Rate Time Trap Identification

- TAKT is one of 3 founding blocks of the **just-in-time** philosophy
- In a continuous flow environment, TAKT is used to balance the cell/line so that inventory is minimized



Example: Calculating TAKT in a single product, multi-step operation



Customer demand: 642 units per shift

Total shift time: 8.5 hours (510 minutes)

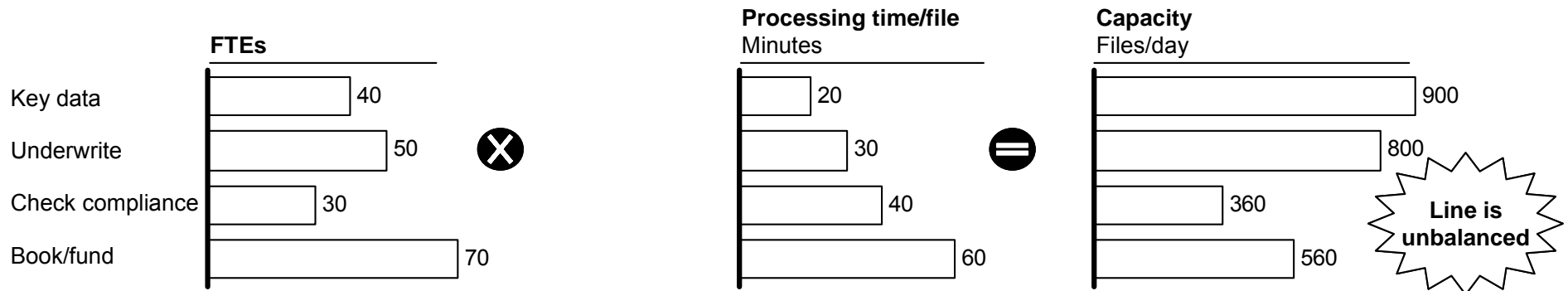
Total time available: 510 minutes - 50 minutes = 460 minutes

Lunch time

$$\text{TAKT time} = \frac{460 \text{ minutes} \times 60 \text{ seconds}}{642 \text{ units}} = 43 \text{ seconds}$$

□ Using Takt Time to Balance the Line

Current process



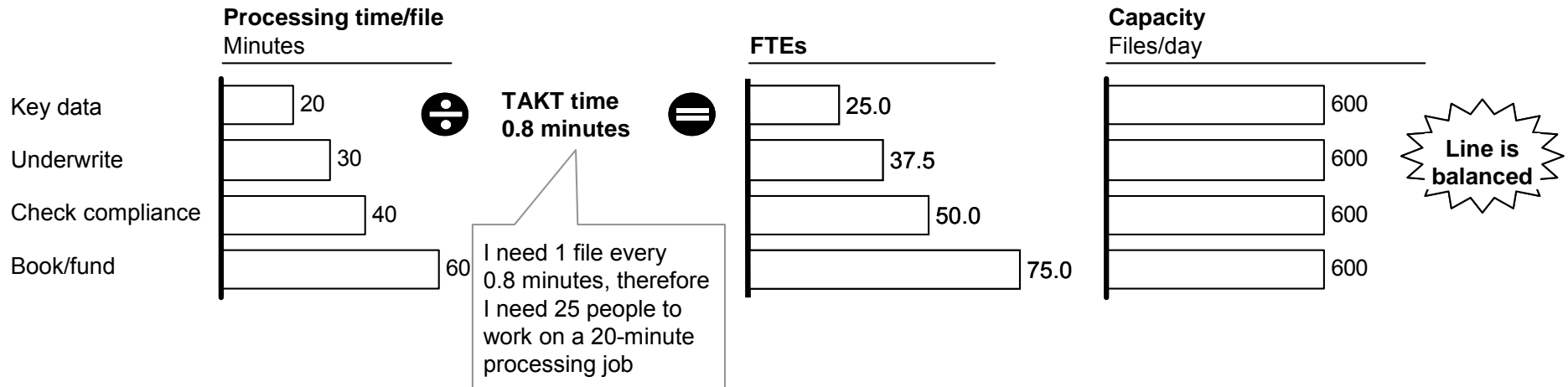
TAKT time calculation

- Time available = 480 minutes (8 hours)
- Customer reward = 600 files/day



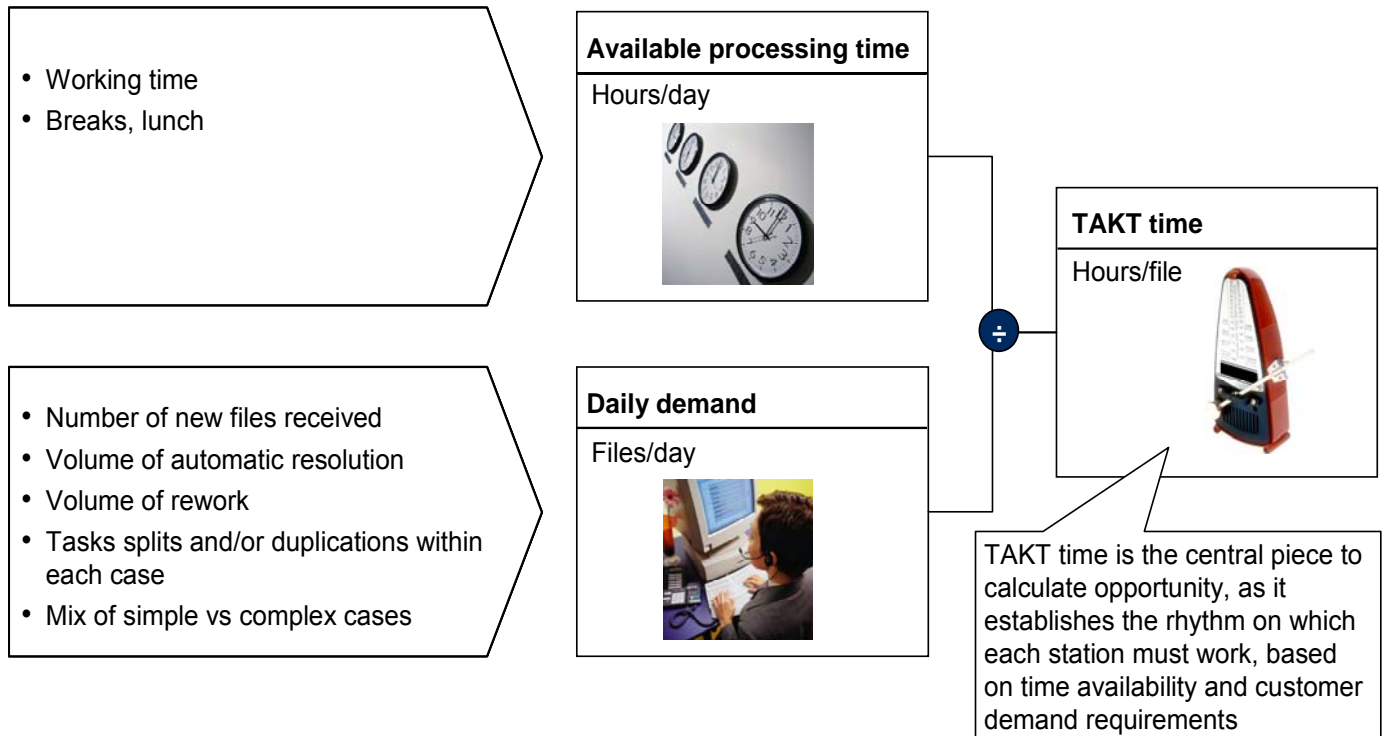
$$\text{TAKT time} = \frac{480}{600} = 0.8 \text{ minutes}$$

Balance line using TAKT time



☐ Takt - Instructions for use to gather relevant data

- For each step, the required input is:



□ Exercise – FTE Requirements using Takt Time

Data: Customer demand: 960 files/day
Working time (8 hrs): 480 minutes/day

<u>Current process</u>	<u>Process Step 1</u>	<u>Process Step 2</u>	<u>Process Step 3</u>	<u>Total FTEs</u>
FTEs	80	50	45	175
Processing time (mins)	30	30	20	
Documents per day	1,280	800	1,080	

Balance process

TAKT time	_____	_____	_____	
FTEs needed by TAKT time	_____	_____	_____	_____
Documents per day	_____	_____	_____	

$$\text{TAKT Time} = \frac{\text{Total Available Production Time}}{\text{Total Customer Demand}}$$

Equals total window of processing time available

Do *not* subtract unscheduled (changeovers, staffing availability, equipment, meetings)

□ Exercise – FTE Requirements using Takt Time– Solution

Data: Customer demand: 960 files/day
Working time (8 hrs): 480 minutes/day

Current process	Process Step 1	Process Step 2	Process Step 3	Total FTEs
FTEs	80	50	45	175
Processing time (mins)	30	30	20	
Documents per day	1,280	800	1,080	

Balance process

TAKT time	0.5	0.5	0.5	
FTEs needed by TAKT time	60	60	40	160
Documents per day	960	960	960	

$$\text{Takt time} = \frac{480 \text{ min/day}}{960 \text{ files/day}} = 0.5$$

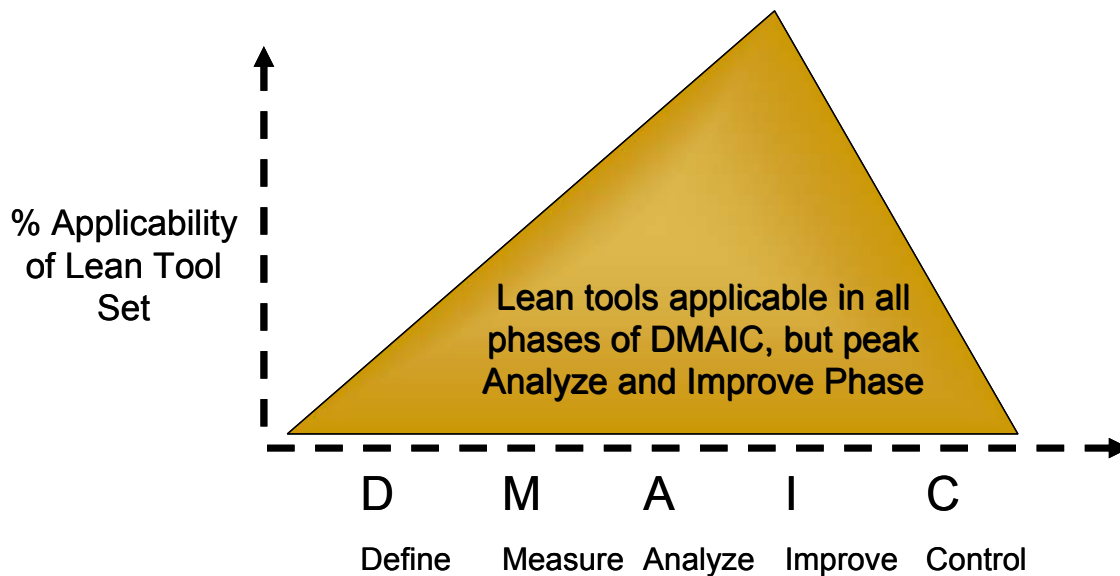
$$\text{FTE} = \frac{\text{Process time/file}}{\text{Takt time}}$$

□ Integration of Lean and Six Sigma

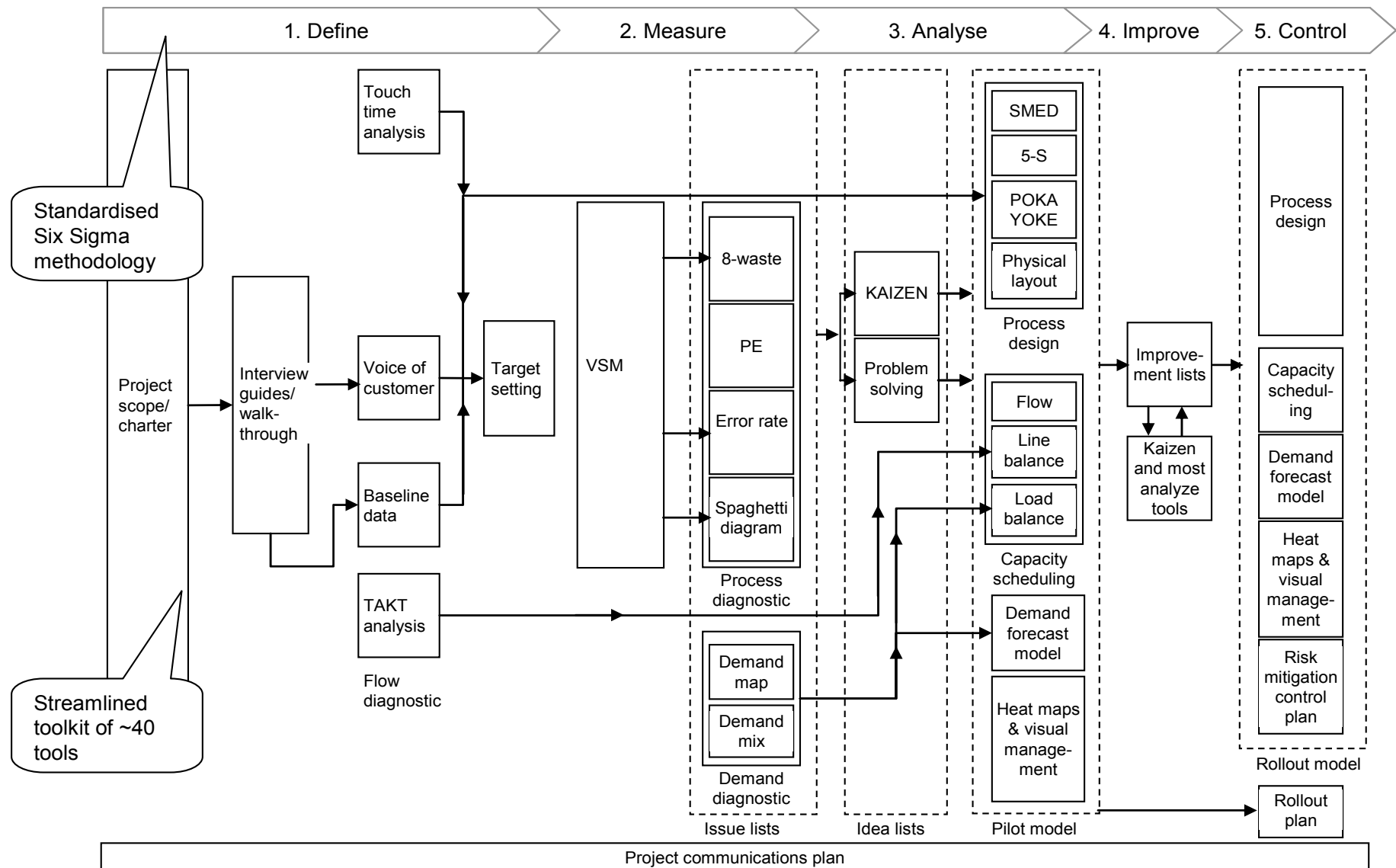
- Lean and Six Sigma can co-exist independently, but the benefits of integration are tremendous...
 - Single channel for employing limited resources
 - One improvement strategy for the organization
 - Highly productive and profitable synergy
- The pitfalls of not integrating them are formidable
 - Six Sigma does not always teach speed tools and therefore does not always attack manufacturing overhead cost and invested capital directly using available best practices
 - Lean lacks defined cultural infrastructure - without CEO engagement, deployment organization (Champions and Black Belts), and focus on customer many lean implementations fail
 - Lean lacks the consistency of the DMAIC philosophy, leading to wide variation in application of tools & techniques
 - Most lean efforts lack focus on variation elimination and simply “account for” the variability by carrying excess inventory and resources
 - Lean Tools do not intrinsically focus on bringing a process under control
- The result
 - Divided focus of the organization
 - Separate and unequal messages for improvement
 - Destructive competition for resources and projects

□ DMAIC Methodology and Lean

- Six Sigma is grounded in the DMAIC philosophy (Define Measure Analyze Improve Control)
- Lean Tools principally apply during:
 - Measure Phase:
 - Value Stream Mapping, Time Trap Analysis, etc.
 - Improve Phase:
 - Pull Systems, Operational Improvements, Work-Cells, etc.
 - Control Phase:
 - Visual Control Tools, Mistake Proofing, etc.
- A “mini-DMAIC” can be applied within each DMAIC phase tool to **Define** problem, **Measure** data, etc. via Kaizen!



SEVERAL LEAN AND SIX SIGMA TOOLS CAN BE APPLIED TO IMPROVE OPERATIONAL PERFORMANCE



□ Takeaways

- There are a variety of techniques and tools to use when attacking a process improvement project, but the DMAIC framework remains intact
- There is a definite path and decision checklist to process improvement, to help in understanding which process improvement tool to apply, and when
 - If the current process capacity is unable to meet customer demand, then the constraint operation must be identified and eliminated as a capacity constraint
 - If the process is simply unbalanced (different workloads for different steps), then it needs to be balanced
- Understand the difference between time traps and constraints and their effect on capacity
- Be able to identify time traps and constraints using takt rate analysis
- “Process Balancing” is a procedure whereby a set of process steps are “equalized” in terms of time required to accomplish them (note “effort” may not be the same!)
- Process balancing tools are used where the process is contained in a defined area
 - Examples include:
 - Order Entry Department
 - Reservation Process
- Key tools used in process balancing are the time study and takt time chart, but other tools such as skill matrix, etc., may play a significant role in the analysis
- The Process Balancing techniques are not exclusive to “one-piece flow” – small batches may be necessary between certain steps – but use of the process balancing tools is meant to drive the process to one-piece flow

□ Lean Enterprise

- Uses **time** and the “relentless pursuit of **waste elimination**” as competitive leverages
- Seeks to make **value flow** from the very first step of the process through to consumption of the service
 - Using least amount of resources (time, people, materials, etc.)
- Creates a **culture** of never-ending **improvement** at all organization levels
- Uses time and the relentless pursuit of *waste* elimination as competitive leverage


 **Waste: Any activity which absorbs resources but does not create *value***

 **Does the activity improve the product or service from the viewpoint of the customer?
If not—it's waste**

Principle #1: The customer defines value

- Seeks to make *value flow* from the very first step of the process through to consumption of the service using the least amount of resources

 **Identify Value Streams (flows of service activity)**


 **No excess inventory or customer waiting
- consumes resources, stifles flow, creates customer dissatisfaction**


Principle # 2: Make value flow - “along streams”

Principle # 3: Provide services to customer demand

☐ Lean Enterprise

- Creates a *culture* of never ending *improvement* at all organizational levels

 Requires an environment where it is safe to experiment & “fail”

 Teamwork is part of cultural fabric

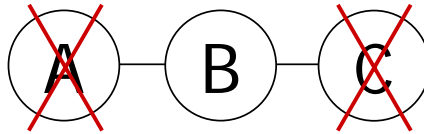
 Cannot tolerate status quo

Principle # 4: Continuous Improvement



Transactional Cycle Time Simulation

“Alphabet Soup”



☐ Learning Objectives

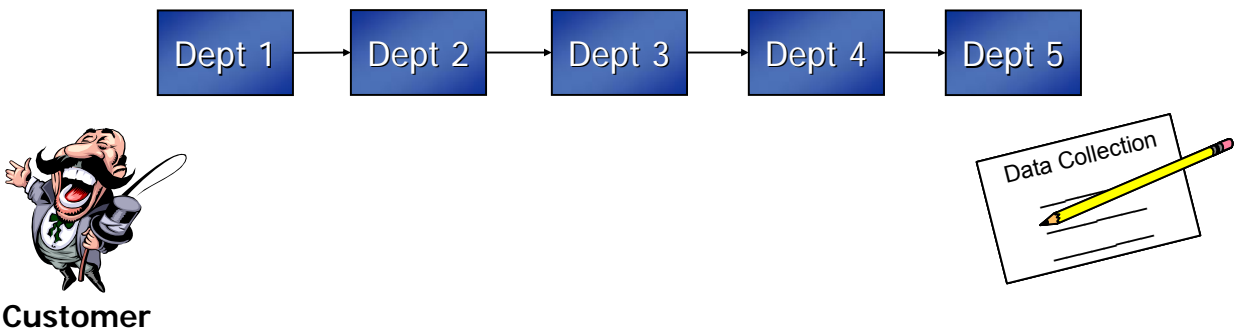
- Demonstrate the fundamental relationship between WIP, Cycle Time, and Exit Rate
- Demonstrate the impact of increasing WIP on a process performance

☐ What's in it for Me?

- When performing process improvements, be able to understand the fundamental drivers of a project to improve cycle time and a project to improve throughput rate
- Understand how WIP drives process inefficiencies

☐ Cycle Time Exercise

- Divide into teams of 5 people
- Arrange seats in an assembly line process
- Assign roles (Departments 1 through 5)

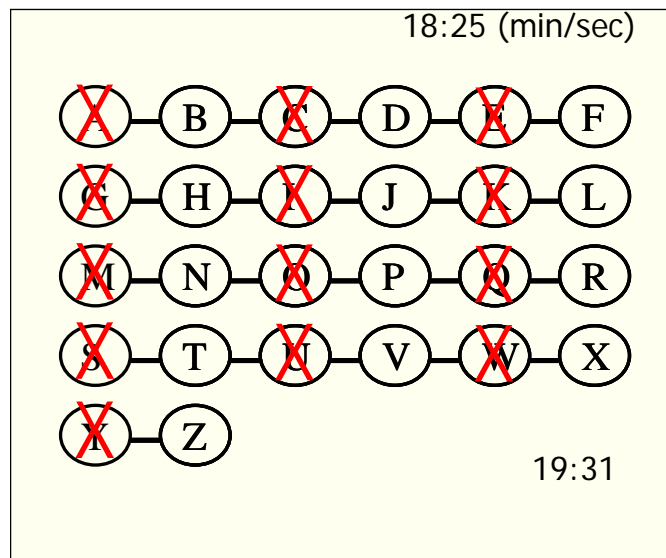


☐ Job Responsibilities

- **Department 1**
 - At pre-defined intervals....
 - Record release time in upper right hand corner of document
 - Release document to Department 2
- **Department 2**
 - Legibly write the entire alphabet in capital letters
- **Department 3**
 - Draw circles around each letter - must be round and not overlap
 - Connect each circle with a straight line
- **Department 4**
 - Put an “X” through every other circle, beginning with “A” and ending with “M”
- **Department 5**
 - Put an “X” through every other circle, beginning with “O”
 - Record completion time in bottom right hand corner of document
 - Calculated total elapsed time for each document (seconds)

Work the documents in the order you receive them!

☐ Example



☐ **Exercise – Part 1a**

- Pilot the process – run one document through the process

☐ **Exercise – Part 1b**

- Run another document through the process
 - The first one was practice
 - This one is real

☐ **Exercise – Part 1b Results**

- What was the cycle time?

	Team 1	Team 2	Team 3
<u>Output</u>	<u>Cycle Time</u>	<u>Cycle Time</u>	<u>Cycle Time</u>

Part 1

Part 2

☐ **Exercise – Part 2**

- Run one document every 10 seconds through the process
- Begin with 1 document of WIP at each of Departments 2-5
- Run for 240 seconds

☐ **Exercise – Part 2 Results**

- How many did we get out?
- What was the cycle time for each document?
- Do you notice a trend? Why?
- How do we get a predictable cycle time?

☐ **Exercise – Part 3**

- Run one document every 30 seconds through the process
- Begin with 1 document of WIP at each of Departments 2-5
- Run for 240 seconds

☐ **Exercise – Part 3 Results**

- How many did we get out?
- What was the cycle time for each document?
- Is the trend the same as Part 2 of the exercise?
- Was each Department fully utilized?
- What happens if we balance the workload throughout the process?

☐ **Exercise – Part 4**

- Department 3 now only draws circles around each letter
- Department 4 connects each circle with a straight line
- Department 5 puts an “X” through every other circle (from A to Z)
- Run one document every 15 seconds through the process
- Begin with 1 document of WIP at each of Departments 2-5
- Run for 240 seconds

☐ **Exercise – Part 4 Results**

- How many did we get out?
- What was the cycle time for each document?
- Observations?
- How do we reduce cycle time?

☐ Takeaways

- Cycle time is related to WIP and exit rate by Little's Law:

$$\text{Process Cycle Time} = \text{WIP} / \text{Exit Rate}$$

- As WIP increases, cycle time increases, but Exit Rate is unaffected
- Exit Rate is controlled by the bottleneck operation
- Exit Rate can be improved by reducing the processing time at the bottleneck workstation
- Cycle time can be improved by reducing WIP or reducing the processing time at the bottleneck workstation